01770

1994/09/00

~~TOP SECRET~~
[redacted]

[redacted]
ONI-1430S-001-94-SAO
SEPTEMBER 1994
[redacted]

OFFICE OF NAVAL INTELLIGENCE

Chinese Space-Based Remote Sensing Programs and Ground-Based Processing Capabilities (U)

PREPARED BY
THE OFFICE OF NAVAL INTELLIGENCE

WARNING NOTICE:
INTELLIGENCE SOURCES OR METHODS INVOLVED

DISSEMINATION AND EXTRACTION OF INFORMATION CONTROLLED BY ORIGINATOR

[redacted]

[redacted]

[redacted]
~~TOP SECRET~~
ENCLOSURE( )

CHINESE SPACE-BASED REMOTE SENSING PROGRAMS AND GROUND-BASED PROCESSING CAPABILITIES (U)

Author:
[redacted]

ONI-1430S-001-94-SAO

DATE OF PUBLICATION
SEPTEMBER 1994

INFORMATION CUT-OFF DATE
31 AUGUST 1994

WARNING NOTICE:
INTELLIGENCE SOURCES OR METHODS INVOLVED

THIS DOCUMENT CONTAINS SPECIAL INTELLIGENCE MATERIAL

DISSEMINATION AND EXTRACTION OF INFORMATION CONTROLLED BY ORIGINATOR

[redacted]

[redacted]

[redacted]

LIST OF EFFECTIVE PAGES (U)

SUBJECT MATTER	PAGE NUMBERS	DATE
TITLE PAGE	None	SEPT 1994
PREFACE (U)	iii (rb)	SEPT 1994
LIST OF EFFECTIVE PAGES (U)	v (rb)	SEPT 1994
TABLE OF CONTENTS (U)	vii-viii	SEPT 1994
LIST OF ILLUSTRATIONS (U)	ix (rb)	SEPT 1994
LIST OF TABLES (U)	xi (rb)	SEPT 1994
EXECUTIVE SUMMARY (U)	xiii (rb)	SEPT 1994
SECTION I (U)	1-8	SEPT 1994
SECTION II (U)	9-11 (rb)	SEPT 1994
SECTION III (U)	13-17 (rb)	SEPT 1994
SECTION IV (U)	19 (rb)	SEPT 1994
GLOSSARY (U)	xv-xvi	SEPT 1994
DISTRIBUTION LIST (U)	xvii (rb)	SEPT 1994

EXECUTIVE SUMMARY (U)

(U) ~~(S-~~[redacted] The Chinese space-based remote sensing program, when fully developed by the year 2000, will provide the Chinese military with electro-optical (EO) and synthetic aperture radar (SAR) data on targets worldwide, which will be of concern to U.S. Navy mission planners. Although only a small percentage of the data will be real-time, the number and sensor diversity of the satellites will provide frequent revisit times and complementary data on military targets, including U.S. naval bases. The satellites will be able to provide an up-to-date in-port order of battle (OOB), and thus be able to monitor U.S. Navy pre-deployment activity.

(U) ~~(S-~~[redacted] The space-based remote sensing program includes the development of an operational photoreconnaissance satellite and a multifaceted earth resources program; the first to support the military, and the second to support the burgeoning population. The Chinese are currently reliant on foreign, primarily Western, remote sensing data to support environmental concerns. They receive foreign remote sensing data, both optical and SAR, from the U.S. Land Satellite (LANDSAT), the French Satellite Pour l'Observation de la Terre (SPOT), the European Space Agency's (ESA) Earth Resources Satellite (ERS)-1, the Japanese Marine Observation Satellite (MOS), and the Japanese Earth Resources Satellite (JERS). Although these satellites are designed for civilian missions, the Chinese undoubtedly are exploiting the data for military purposes.

[redacted]

(U) ~~(S-~~[redacted] China could have a fully developed earth resources remote sensing program by the year 2000. Satellites under development include those in at least two earth resources satellite programs [redacted] which will offer data with resolutions of between 13 and 26 m. Other satellites include an Ocean Satellite (OCEANSAT) [redacted]CEANSAT) and a SAR satellite.

(U) Currently, the Chinese space program is heavily reliant upon Western space technology and components, both in building satellites and in processing the data. To become more self-sufficient, China has embarked on a major renovation of its space industry, and hopes to attain world standards in space technology within five years. Expeditious avenues, such as reverse engineering and international cooperative efforts, will be exploited for transfer of the needed technology.

(U) ~~(C~~[redacted] The Chinese are making great strides in remote sensing data application, processing, and manipulation. [redacted] The Chinese have demonstrated aptitude in the areas of data processing and manipulation, both of which can be directly transferred to military use. These areas include techniques in data extraction, use of geographic information systems (GIS), mapping, and target identification.

[redacted]

B. FUTURE REMOTE SENSING SATELLITES (U)

(U) ~~(C)~~ [redacted] In addition to deploying an operational photoreconnaissance satellite by the year 2000, China could also have a fully developed indigenous remote sensing capability comprised of one or more of the following satellite systems:

- a multispectral imagery (MSI) [redacted]
- a prototype real-time SAR equipped satellite,
- a possible OCEANSAT, and
- a cooperative earth resources satellite called the Chinese-Brazilian Earth Resources Satellite (CBERS).

[redacted]

[redacted]

2. OCEANSAT (U)

(U) An ocean environmental monitoring satellite is also being considered. Although no sensor specifics are known to date, it could well be similar to that of the Japanese MOS, which is an EO system with a 50 m resolution designed to monitor marine resources. References to a satellite called OCEANSAT were noted in an article discussing a modular approach to future Chinese satellite designs. The article offered two satellite bus designs: the TTS-1 design to be used for meteorological and ocean monitoring satellites, and the TTS-2 design for disaster monitoring and radar satellites. Satellite bus specifications are as follows:

	TTS-1	TTS-2
Mass (kg)	1500	2500
Payload mass (kg)	500-600	800-1000
Dimensions (m)	2x1.8x1.2	2x1.8x1.5
Instrument mounting area*	3.6	8
Solar array power Watts (W)	550-1100	1100-2200
Available Payload power (W)	130-600	260-1200
Space Launch Vehicle (SLV)	LM-4	LM-4

[redacted]

3. SYNTHETIC APERTURE RADAR (SAR) SATELLITE (U)

(U) (~~S~~) The Chinese are also pursuing development of a SAR-equipped satellite, and could launch a prototype by the year 2000. While current SAR data can be used to detect and determine the course and speed of ships in the ocean, it has been unable to actually identify the ships. This detection capability is further dependent upon the radar band and detection angle chosen for the SAR.

[redacted]

4. COOPERATIVE AGREEMENTS: CBERS (U)

(U) (~~S~~ [redacted]) In July 1988, Brazil entered into a joint remote sensing satellite venture with China. The two countries signed an accord to jointly construct two identical CBERS. [redacted] China has invested $105 million dollars, and is responsible for 70 percent of the project, while Brazil has contributed $45 million dollars and assumed 30 percent of the project. Likewise, the two countries will receive the derived data in the same 70 to 30 percent ratio. Brazil's Institute for Space Research (Instituto de Pesquisas Espacias (INPE), and the Chinese Academy of Space Technology (CAST), are the principal participant agencies

in the arrangement. China will provide most of the satellite, including the optics. INPE is responsible for construction of the satellite structure, data collection system, S-band transponder, electrical support equipment, energy supply system, computers, and orbit/altitude control system. Both satellites will weigh 1450 kg, be placed into a 778 km, 98.5 degree sun-synchronous orbit, and have a two year operational life.

(U) ~~(C~~[redacted] CBERS-1, originally scheduled to be launched by 1994, is now programmed for 1996. This satellite will provide data on geological features, oceanography, forestry, farm products, and other earth resources to both China and Brazil. The information collected from CBERS-1 will cover 9.6 million square kilometers (km) of land and sea, and will be available commercially. This data will also be downlinked to both Cuiaba and Beijing. (See Table I for the orbital parameters of CBERS).

(U) CBERS will be equipped with three cameras. A CCD narrow field imaging device with 5 bands (0.51 to 0.89 microns) will provide a ground resolution of 20 m. The infrared multispectral (IR-MSS) camera will have ground resolutions of 80 m and 160 m for thermal detection. The CCD wide field imager (WFI) will furnish a ground resolution of 260 m, and the high resolution coverage will also have a zoom command capability. (Table II and Figure 2). CBERS-2, if developed, will be launched about two years after CBERS-1.

Table I. (U) CBERS ORBITAL PARAMETERS

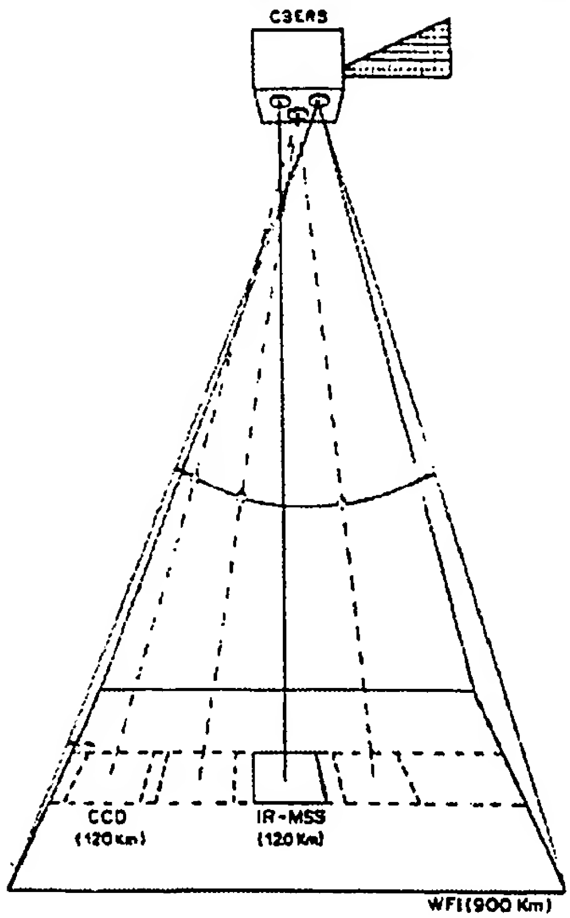
ORBITAL PARAMETERS	
Mean Altitude	778km
Inclination	98.504 degrees
Revolutions/Day	14 + 9/26
Nodal Period	100.26 min.
Mean Local Solar Time at Descending Node	10h 30m
Earth Coverage Period	26 days

(UNCLASSIFIED)

Table II. (U) IMAGING SENSOR

IMAGING SENSOR			
CHARACTERISTICS	CCD	IR-MSS	WFI
Spectral Band (μm)	0.51 - 0.73 (pan) 0.45 - 0.52 0.52 - 0.59 0.63 - 0.69 0.77 - 0.89	0.50 - 1.10 (pan) 1.55 - 1.75 2.08 - 2.35 10.40 - 12.50	0.63-0.69 0.76 - 0.90
Spatial Resolution	20m	80m for pan & medium IR bands 160m for the thermal band	260m
Temporal Resolution	Nadir view 26 days, off nadir view (±32°) 3 days	26 days	3-5 days
Ground Swath Width	120km	120km	900km

(UNCLASSIFIED)



(UNCLASSIFIED)

Figure 2. (U) CBERS Imaging Modes.

[redacted]

a. Charged Couple Devices (CCDs) (U)

[redacted]

(U) To free themselves from their current dependence on U.S.-made CCDs for space-based applications, the Chinese are now devoting considerable time, energy, and capital to CCD development. Although much of the research and development is earmarked for civilian and commercial applications, the research is producing CCD technology which can be used for space-based remote sensing and other military applications.

(U) Advertised successes primarily involve the 44th Institute of the Ministry of Machine-Building and Electronics Industry (MMEI), which has already developed 128-, 512-, 1024-, 2048-, 1728-, 2500-, and 440,000 pixel linear array CCDs. The 440,000-pixel CCD probably projects a high resolution image, such as that used in remote sensing, reconnaissance, missile guidance, and image transmission measuring. The 3- to 5- micrometer 512-bit IR CCD can be used for IR thermal imaging in space surveys. Based on the completion of the 512-bit IR CCD, the development of a 256 x 256 element CCD is now possible. Consequently, China probably is ready to manufacture a thermal imaging system of even higher resolution.

(U) Another success of the 44th Institute is its recent development of China's first million-pixel planar array device. This array currently has the nation's highest pixel count, and may soon meet the international standards for planar array 1024 x 1024-pixel high-resolution CCDs. The device uses a complete frame signal with imaging quality. Its development can promote further applications of CCDs required in such areas as space remote sensing, aeronautics, missile guidance, and range tracking.

b. Ancillary Technology (U)

(U) In addition to developing CCDs, China is attempting to improve the resolution of its remote sensors. Engineers at the Beijing Institute of Electromechanical Research & Design are working on the development of a phase-locked-loop speed control system that improves the resolution of remote sensors by accurately compensating for motion. The system, built around a type CD4046 CMOS frequency phase detector, is designed for a remote sensor with a focal length of 1 m, a velocity of 7.8 km/sec and an altitude of 200 km. This design can meet the requirements for a future earth resources satellite, which requires a remote-sensing ground resolution of 5 m.

c. Future Optical Remote Sensors (U)

(U) China is also looking ahead into the future to discern the needed requirements of optical sensors. The depth of the Chinese concern, and also their understanding of future requirements, are particularly well illustrated in a paper presented by Ma Wenpo, an M.S. student at the Beijing Institute of Space Machine and Electricity, CAST. According to the present level and developmental speed of the optical remote sensors, he predicts that these sensors, in the next century, will incorporate many of the following features:

- wide spectral range, which can cover from ultraviolet (UV) to longwave-IR,
- many spectral bands; there could be several hundred bands or more,
- high spectral resolution; some special bands could attain a spectral resolution of 1 nautical mile (nm) or less,
- high spatial resolution, perhaps reaching 1 m or even smaller to meet some special need,
- high radiometric resolution; the 12-14 bit precision will be obtained, so it is necessary to greatly decrease the noise of the detector and electronics,
- high radiometric calibration precision; the absolute calibration precision will be approximately +/- 1.5 percent,
- CCD linear-array and area-array, which are employed as detectors,
- intellectualization; the image data can be real-time-processed on the satellite, and
- multifunction; the spectral bands, the width of the bands, and the spatial resolution will be adjustable in orbit by telemetry command. Two or three dimensional images of the land, ocean and atmosphere can be obtained from different directions, and the polarized image will be acquired for polarimetric measurement.

Although this "vision" is well known in the West and in Japan, the fact that a Chinese research paper mentions these attributes implies that the Chinese have very serious intent.

SECTION III
REMOTE SENSING PROCESSING AND APPLICATIONS (U)

A. PROCESSING (U)

[redacted]

(U) The Chinese are also conducting proprietary research on the problems of processing RSI imagery received from remote sensing satellites. One such example is the study presented by the Beijing Institute of Satellite Information Engineering on techniques for a high data-rate satellite ground processing system, or Quick Look System.

[redacted]

(U) Several other Chinese institutes are also involved in processing remote sensing data, and many, many more are utilizing the data. Some of the main remote sensing data processing organizations are described below.

[redacted]

(U) Academic institutes are also included. In 1985. the Degree Commission of the State Council appointed the University of Qingdao as the unique postgraduate school for ocean physics, to include remote sensing, ocean acoustics, and ocean optics. Currently, close to 80 percent of the advanced oceanic researchers and major institutes are located here, including the Academy of Science, State Oceanography Administration, Aquatic Ministry, and the Ministry of Geologic and Mineral Resources. The State Science and Technology Commission of China is currently establishing a high tech industrial region in Qingdao. This area could develop into one of the main remote sensing research centers of China, especially in the area of oceanic research.

B. APPLICATIONS (U)

1. OCEAN REMOTE SENSING (U)

(U) As reported by the Ocean University of Qingdao during the PORSEC-1 Conference held in Okinawa in August 1992, China has been pursuing an ocean remote sensing program since the late 1970s. The program has progressed from its developmental stage, which relied on airborne platforms, to an operational program which now uses space-based remote sensing data from a number of satellites. Some examples of this growth are described below.

a. (U) In the 1978-1980 timeframe, research was developmental. China conducted two comprehensive, large scale aerial ocean remote sensing experiments using the airborne sensors from which the IR-MSS for China's first weather satellite, FY-1, was developed.

b. (U) From 1980 to 1985, ocean remote sensing research progressed from experimental to applied aspects, and focused on two tests of coastal zone remote sensing and basic research for ocean remote sensing. This phase marked the first incorporation of satellite data into China's ocean remote sensing program, and the introduction of digital image processing systems. LANDSAT and the National Oceanic and Atmospheric Administration (NOAA) receiving stations were established in Beijing, while some universities introduced a number of digital image processing systems under the support of the World Bank.

c. (U) The period of 1985-1990 witnessed the continued development of ocean remote sensing and satellite oceanography, with the marked addition of large scale and designated projects. One such project that originated during this time was entitled the "Ocean Environment Numeric Forecast". This undertaking emphasized appreciation of NOAA data, and reception capability which had been greatly expanded from one to seven sites. Satellite ocean remote sensing efforts focused on a receiving/processing system for NOAA data, retrieval techniques of sea surface temperature, and sea ice monitoring software. Further, Qingdao University and the Environment Forecast Center (EFC) have produced NOAA and Geostationary Meteorological Satellite (GMS) data receiving/processing equipments based on IBM-386 and 486 computers. The second developmental stage is ongoing through 1995, and will focus on national and international ocean remote sensing programs.

(U) One of the five-year national plan projects, entitled "Disastrous Ocean Environment Numeric Forecast", identifies subprojects involving the satellite RSI. Some of these undertakings include:

- the operation system of NOAA data processing and product dissemination,
- a ten day forecast and a seasonal projection of the sea surface temperature in the Northwest Pacific using GMS real-time data,
- remote sensing of sea surface parameters such as sea surface temperature, sea wave, sea surface height, surface wind field, and sea ice, using ERS-1 data, and
- validation of related numeric forecast models.

(U) Other national goals fall under the auspices of two key projects, "Research on Ocean Flux of Continental Shelf in East Sea" and "Research on Circulation of Continental Shelf in China Seas and Its Dynamic Mechanism", both of which are undertaken by the State Natural Science Fund Commission. These projects will use multiple satellite data types supplied by a number of satellites, including CZCS, GEOSAT, ERS-1, FY, MOS, SEAWIFS, TOPES/POSEIDON, ERS-2, and EOS.

(U) China participated in ESA's project entitled "Validation and Research of ERS-1 data in the China Seas and NW Pacific Ocean." Applications of this project included acquisition of sea surface height and wave height by altimeter data, directional wave spectrum from SAR, and sea surface wind field by scatterometer, including retrieval algorithm and influence of sea surface temperature on wind field fluctuation. Recently, China and Japan have agreed to cooperate in gathering earth science and ocean data on the North Pacific, an effort which will presumably utilize satellite data.

(U) The next phase of Chinese ocean remote sensing, building on the ERS project, will continue the work of ocean microwave remote sensing technology, based on satellite-borne microwave altimeters, scatterometers, and SAR. Future programs will include the research program "Ocean High Technology with RSI as a Component."

2. MAPPING (U)

[redacted]

[redacted]

[redacted]

b. (U) In another example, the State Bureau of Surveying and Cartography (SBSC) of China has introduced advanced domestic and foreign produced techniques to modernize surveying and mapmaking methods. They have successfully developed a software package, which is the core of an all-digital automated mapping system, and provides an image matching speed of up to 200 points per second. Using this software, the Chinese now have the capability to process satellite images equivalent to 360 square km of ground surface within 30 minutes, and to produce contour lines accurately and promptly. A major factor accelerating surveying and mapping accuracy is the recent introduction and now extensive use of GPS.

[redacted]

SECTION IV
CONCLUSIONS (U)

(U) ~~S~~ [redacted] China can achieve its goals in space-based remote sensing by the year 2000, only if it acquires the needed technology. If most of the projected systems are deployed, China will have not only an operational photoreconnaissance satellite, but also a constellation of earth resources satellites, which will provide the Chinese military with an array of complementary multi-sensor data. The successful and timely fusion (remote sensing data processing) of the diverse sensor data will enable the Chinese to achieve very precise target identification.

(U) ~~S~~ [redacted] Further, the Chinese remote sensing space program is another element, especially when combined with other projected remote sensing and reconnaissance programs, which will greatly complicate U.S. Navy mission planning in the future.